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(54) **METHOD AND APPARATUS FOR CONTROLLING THE FLOW OF MOLTEN STEEL IN A MOULD**

VERFAHREN UND VORRICHTUNG ZUR FLUSSSTEUERUNG VON STAHLSCHELZE IN EINER FORM

PROCÉDÉ ET APPAREIL POUR COMMANDER L'ÉCOULEMENT D'ACIER FONDU DANS UN MOULE

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Description

TECHNICAL FIELD

[0001] The present invention relates to a method and an apparatus for controlling a flow of molten steel in a mould using a continuous slab casting machine, and a method for producing a slab using the flow control method and apparatus.

BACKGROUND ART

[0002] One of the quality factors required for a cast product to be produced by a continuous slab casting machine is a reduced amount of inclusions entrapped in the surface layer of the cast product. Such inclusions to be entrapped in the cast product surface layer are, for example:

- (1) deoxidation products occurring in a deoxidation step using aluminium and the like and suspending in molten steel;
- (2) Argon gas bubbles blown into molten steel in a tundish or blown through an immersion nozzle; and
- (3) inclusions occurring with mould powder sprayed on a molten steel bath surface and entrained into the molten steel as suspending substances.

[0003] Any of these inclusions causes surface defects in steel products, so that it is important to reduce any kind of inclusions. By way of means for reducing, for example, deoxidation products and argon gas bubbles among the above described inclusions, there are popularly used processes of the type to prevent entrapment of inclusions in such a manner that intra mould molten steel is driven to move in the horizontal direction, and a molten steel velocity is thereby imparted to the surface of the molten steel to clean a solidifying surface. A practical process of applying a magnetic field for rotating the intra mould molten steel in the horizontal direction is carried out in such a manner that the magnetic field moving horizontally along the directions of long sides of the mould is driven to move in the directions opposite to each other along the opposing long side surfaces to induce a molten steel flow that behaves to rotate in the horizontal direction along the solidified surface. In this document, the application process is referred to different stirring modes, see various descriptions below, as "EMDC," "EMDC-mode," or "EMDC-mode magnetic field application" in combination with "EMLA," "EMLA-mode," "EMLA-mode magnetic field application" and/or "EMRS," "EMRS-mode," "EMRS-mode magnetic field application".

[0004] The EMDC, Electro Magnetic Direct Current, braking technology, with the stirrer in a low position in the mould, is by far the most dominant technology in general and it will therefore also be possible to fix the frequency down to zero and adjust the phase angle for highest magnetic flux density in the mould. DC technology

has many advantages in general, such as stability and self-regulating, i.e. if the flow velocity is higher on one side, the braking force will also be higher. In comparison with very low frequency of 1Hz or less, DC magnetic field in the lower part of the mould can give a more stable braking control of the fluid flow in the mould.

[0005] When operating in the Electromagnetic Level Accelerating mode, EMLA, with the stirrer in a low position in the mould, the outward flow speed of the steel, towards the narrow sides, is accelerated and thereby ensuring that a dual flow pattern is achieved also for low speed casting. The optimization of the flow in the mould involves the creation of a stable two-roll flow pattern. By choosing mode and the right FC MEMS, see description below, parameters, the requested flow-pattern can be achieved at different slab geometries and casting speeds. Instead of using the analytical F-value, this can be controlled by the FC MEMS with the use of a database containing relevant parameters for different operating conditions. These parameters are usually being generated by a numerical 3D-modelling package, EM Tool, which is modelling the magnetic field, fluid flow and temperature behaviour in the mould. When operating in EMLA mode the FC MEMS should be shifted to its lower position. For low casting speeds, the FC MEMS can accelerate the fluid flow towards the narrow face in order to assure a normal flow in the mould. The F-value is converted into the molten steel surface flow velocity. However, as described in EP-A-1486274, the F-value and the molten steel flow velocity have the one-to-one relationship, so that the control can be performed by using the F-value without conversion into the molten-steel surface flow velocity.

[0006] The slab mould stirrer type FC MEMS consists of one set of stirrers per mould. Each set of stirrers consists of four linear part stirrers. The two part stirrers on each side of the mould are built together into a stirrer unit in an outer casing, and are mounted in the existing pockets behind the backup plates in the wide side water jackets. Two opposite part stirrers are connected in series and are connected to one frequency converter. Totally two frequency converters are required for one mould, and the stirrer is designed and manufactured for continuous operation in the mould. The stirrer converts the low frequency currents from the frequency converter into a low frequency magnetic field, and said magnetic field penetrates the mould copper plates and the solidified shell of the strand and induces electrical currents in the liquid steel. These currents interact with the travelling magnetic field and create forces and thus movements in the liquid steel. The stirrer comprises windings and a laminated iron core. The stirrer windings are made of copper tubes with rectangular cross section and are directly cooled from the inside by de-ionized fine water circulating in a closed loop system. The stirrer is enclosed in a protective box with sides made from nonmagnetic steel sheet and the front made from nonconductive material.

[0007] Electromagnetic Rotative Stirring mode,

EMRS, which is the dominating technology for stirring in a mould takes place in the upper part of the mould close to the meniscus and the position of the stirrer is of vital importance for a controlled stirring of the fluid flow. For controlled and optimum stirring it is imperative to stir at a high position in the mould and the FC MEMS must therefore be shifted upwards. Stirring in a low position will conflict with the flow exiting the nozzle and give an uncertain and turbulent flow in the mould. It is therefore proposed that the stirrer is shifted upwards with when changing from EMLA-/EMDC-mode to stirring mode. The FC MEMS generates a rotational force on the steel in the mould. The frequency converter set up allows for a lower current to be applied on the two coils where the flow is directed towards the narrow sides and thereby giving the possibility to optimize the stirring parameters. The two frequency converters, however, need to be synchronised in frequency in order to minimize possible disturbance.

[0008] An example of a similar process as described above is described in European Patent Application 1486274 (JFE Engineering Corporation) in which a EMLS, Electromagnetic Level Stabilizer, is used in combination with EMLA and/or EMRS.

SUMMARY OF THE INVENTION

[0009] The present invention provides an improvement to a method and an apparatus for controlling a molten steel flow velocity on a molten steel bath surface, meniscus, in a mould to a predetermined molten steel flow velocity using a continuous slab casting machine, and a method for producing a slab using the flow control method and apparatus.

[0010] This is achieved by applying a static magnetic field to impart a stabilizing and braking force to a discharge flow from an immersion nozzle when the molten steel flow velocity on the meniscus is higher than the mould powder entrainment critical flow velocity and by controlling the molten steel flow velocity on the molten steel bath surface to a range of from an inclusion adherence critical flow velocity or more to a mould powder entrainment critical flow velocity or less by applying a shifting magnetic field to increase the molten steel flow when the molten steel flow velocity on the meniscus is lower than the inclusion adherence critical flow velocity.

[0011] When a molten steel flow velocity on a meniscus is higher than a mould powder entrainment critical flow velocity of 0.32 m/sec, the molten steel flow velocity is controlled to a predetermined molten steel flow velocity by applying a static magnetic field to stabilize and impart a braking force to a discharge flow from an immersion nozzle. When the molten steel flow velocity is lower than an inclusion adherence critical flow velocity of 0.20 m/sec and is higher than or equal to a bath surface skinning critical flow velocity of 0.10 m/sec, the molten steel flow velocity is controlled to the range of 0.20-0.32 m/sec by applying a shifting magnetic field to rotate the intra mold molten steel in a horizontal direction. When the molten

steel flow velocity is lower than the inclusion adherence critical flow velocity, the molten steel flow velocity is controlled to the range of 0.20-0.32 m/sec by applying a shifting magnetic field to impart an accelerating force to the discharge flow from the immersion nozzle.

[0012] The FC MEMS will operate at different modes, e.g. EMLA, EMRS and EMDC, and the design of FC MEMS differs in several aspects from other stirring equipment:

- The stirrer is designed for three phase current which eliminates one cable per phase compared to a two phase system. In case a three phase standard converter is used, the maximum phase current to the coil can also be minimized. A two phase system requires $\sqrt{2}$ larger phase current in the common return line. The standard converter system for stirrer applications has been modified and also includes the feature to have symmetry in the different phase currents. The higher symmetry achieved in the phase currents the higher performance can be achieved by the stirrer. A normal frequency converter will operate with common phase voltages and as the mutual inductances between the different windings differ, this will result in different phase currents;
- The FC MEMS-design contains a coil capable of creating a static magnetic field for EMDC and a shifting magnetic field for EMLA and EMRS. The shifting magnetic fields for EMLA and EMRS are created by using polyphase AC-currents to feed the coil. Corresponding static magnetic fields will be created by feeding direct current in the different phases and by feeding with different current intensity in the different phases the distribution of the magnetic fields acting on the mould will differ and consequently the braking impact will also differ in different parts of the mould. It may be an advantage to vary the brake effect over time and consequently it is desirable to change the relationship between the DC-currents in the phases over time. Since the time for creating a certain flow pattern is at least 10 seconds, it is desirable to be able to vary the DC-current within said time;
- The stirrer is designed for EMLA (accelerating mode) and EMRS (stirring mode). Rated current can be used at frequencies between 0,4-2 Hz. The stirrer is protected in a stainless steel casing and a slight over pressure of dry air is used for avoidance of moisture. The stirrer unit has double inlets and outlets for cooling water. One or the other set is used depending on stirrer position in the mould and the other is blocked.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The present invention will be described in more detail in connection with the enclosed schematic drawings.

Figure 1 is a schematic view of the continuous slab casting machine used when carrying out the present invention in an EMRS mode.

Figure 2 is a schematic view of the continuous slab casting machine used when carrying out the present invention in an EMLA mode.

Figure 3 is a schematic view of the continuous slab casting machine used when carrying out the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Embodiments of the present invention will be described herein below with reference to the accompanying drawings. Figures 1 and 2 are each schematic views of a continuous slab casting machine used when carrying out the present invention. More specifically, figures 1 and 2 are both schematic perspective/front views of a mold portion according to the present invention.

[0015] Referring to figure 1 and 2, a tundish (not shown) is disposed in a predetermined position over a mold (1) that has mutually opposite mold long sides (2) and mutually opposite mold short sides (3) internally provided between the mold long sides (2). An immersion nozzle (4) having a pair of discharge openings (5) in a lower portion is disposed in contact with an undersurface of a sliding nozzle (not shown) connected to the tundish. A molten steel outflow opening (6) is formed for the molten steel outflow from the tundish to the mold (1). On the rear surfaces of the mold long sides (2), four magnetic field generating apparatuses (7) in total are disposed in separation into two opposite sides in the left and right with respect to the immersion nozzle (4) as a boundary in the width direction of each of the mold long sides (2). The generators on the individual sides are thus disposed with the mold long sides (2) being interposed to have a center position in a casting direction thereof as an immediate downstream position of the discharge openings (5). The individual magnetic field generating apparatuses (7) are connected to a power supply (not shown) and the power supply is connected to a control unit (not shown) that controls the magnetic field movement direction and the magnetic field intensity. The magnetic field intensity and the magnetic field movement direction are independently controlled by electric power supplied from the power supply in accordance with the magnetic field movement direction and magnetic field intensity having been input from the control unit. The control unit is connected to a process control unit (not shown) that controls the continuous casting operation, whereby to control, for example, timing of magnetic field application in accordance with operation information sent from the process control unit.

[0016] In the event of EMRS-mode magnetic field application for inducing molten steel flow such as rotating in the horizontal direction on the solidifying surface, as shown in figure 1, the movement directions of the shifting

magnetic field are set opposite to each other along the mold long sides (2) opposite to each other. In the event of EMLA-mode magnetic field application for imparting the accelerating force to the molten steel discharge flow (8) discharged from the immersion nozzle (4), as shown in figure 2, the movement directions of the magnetic field are set to the mold short sides (3) side from the immersion nozzle (4) side. According to figure 1, although the shifting field is set to a movement mode such as rotating clockwise, advantages are the same even when the magnetic field moves counterclockwise.

[0017] Meanwhile, figure 1 and 2, respectively are views of the movement directions of the magnetic field being applied according to the EMRS and EMLA modes, as viewed from a position just above the mold (1), in which the arrows indicate the movement directions of the magnetic field.

[0018] In lower portions of the mold (1), there are situated a plurality of guide rolls (not shown) for supporting a cast product (not shown) that is to be produced by casting and a plurality of pinch rolls (not shown) for withdrawing the cast product.

[0019] Molten steel is poured from a pan (not shown) into a tundish (not shown). When the molten steel amount reaches a predetermined amount, a slide plate (not shown) is opened to allow the molten steel to be poured into the mold (1) through the molten steel outflow opening (6). The molten steel forms the molten steel discharge flow (8) proceeding to the mold short sides (3), and is then poured into the mold (1) from the discharge openings (5) immersed in the molten steel in the mold (1). The molten steel poured into the mold (1) is cooled by the mold (1), thereby forming a solidifying shell (not shown). When a predetermined amount of the molten steel has been poured into the mold (1), the operation starts with withdrawal of the cast product (not shown) containing un-solidified molten steel in its inside with an outer shell as the solidifying shell. After the withdrawal is started, while the position of the molten steel meniscus (9) is being controlled to a substantially constant position in the mold (1), and the casting speed is increased to a predetermined casting speed. A mold powder is then added to the meniscus (9) in the mold (1). The mold powder is melted, thereby exhibiting the effect of, for example, preventing oxidation of the molten steel. Concurrently, the molten mold powder flows between the solidifying shell and the mold (1) and thereby exhibits an effect as a lubricant. In the casting operation, the molten steel flow velocities in the mold (1) short side (3) vicinity on the meniscus (9) are determined corresponding to the individual casting conditions.

[0020] One of the methods for determining the molten steel flow velocity is of a type that predicts the molten steel flow velocity on the meniscus (9) by using known equations in accordance with the each individual casting condition.

[0021] Another method is of a type that actually measures the molten steel flow velocity on the meniscus (9).

When a casting condition has been determined and set, the molten steel flow velocity on the meniscus (9) is substantially constant under that condition. As such, when molten steel flow velocities in the meniscus (9) under the individual casting conditions are preliminarily measured, the flow velocity can be determined from the corresponding casting condition. In this case, the actual measurement value of the molten steel flow velocity may be preserved, and the preserved actual measurement value of the molten steel flow velocity may be determined as the molten steel flow velocity. The molten steel flow velocity can be measured in such a manner that a thin rod of a refractory material is immersed in the meniscus (9), and the flow velocity can be measured from kinetic energy received by the thin rod.

[0022] In the event that the molten steel flow velocity in the mold (1) short side (3) vicinity on the meniscus (9) is lower than or equal to the inclusion adherence critical flow velocity, more specifically, lower than 0.20 m/sec, the shifting magnetic field is applied according to the EMRS or EMLA mode.

[0023] In the event that the molten steel flow velocity in the mold short side vicinity on the molten steel meniscus (9) is higher than the mold powder entrainment critical flow velocity, more specifically, higher than 0.32 m/sec, the static magnetic field is applied according to the EMDC mode.

[0024] Further, in the event that the molten steel flow velocity in the mold short side vicinity on the meniscus (9) is less than the inclusion adherence critical flow velocity, the application process for the shifting magnetic field is separated into two sub processes.

[0025] In the event that the above described molten steel flow velocity is less than the meniscus skinning critical flow velocity, more specifically, lower than 0.10 m/sec, the shifting magnetic field is preferably applied according to the EMLA mode.

[0026] In the event that the above described molten steel flow velocity is less than the inclusion adherence critical flow velocity and concurrently higher than or equal to the meniscus (9) skinning critical flow velocity, more specifically, 0.10 m/sec or higher and lower than 0.20 m/sec, the shifting magnetic field is preferably applied according to the EMRS mode.

[0027] In the manner described above, by continuously casting the molten steel while controlling the molten steel flow in the mold (2), the cast product, a clean, high quality cast product can be steadily produced by casting even over a wide range of casting speeds not only with very small amounts of substances such as deoxidation products and Argon gas bubbles but also with a very small amount of entrainment of the mold powder.

[0028] The present invention is not limited to the embodiments disclosed but may be varied and modified within the scope of the following claims.

Claims

1. An apparatus for controlling a flow of molten steel in a continuous slab casting machine, comprising a mould (1) arranged for receiving a flow of molten steel, an immersion nozzle (4) comprising discharge openings (5) immersed in the molten steel in the mould and supplying the flow of molten steel into the mould (1), and control means, the apparatus comprising:

- casting-condition acquiring means for acquiring at least one condition as casting condition on a cast product thickness, a cast product width, a casting speed, an amount in inert gas injection into a molten steel outflow opening, and an immersion nozzle shape,
- calculating means for calculating a molten steel flow velocity on the meniscus of the molten steel in the mould, in accordance with the acquired casting condition,
- determining means for determining a stirring mode to be applied based on whether the calculated molten steel flow velocity is higher than a mould powder entrainment critical flow velocity, whether the molten steel flow velocity is lower than an inclusion adherence critical flow velocity and is higher than or equal to a meniscus skinning critical flow velocity, and whether the molten steel flow velocity is lower than the meniscus skinning critical flow velocity by comparing the calculated molten steel flow velocity with the mould powder entrainment critical flow velocity, the inclusion adherence critical flow velocity, and the meniscus skinning critical flow velocity,
- a first magnetic field generator (7) for generating a magnetic field including a first coil capable of creating a shifting magnetic field in accordance with an output of the control means,
- a polyphase AC current power source connected to the first magnetic field generator
- control means adapted for controlling the magnetic field movement direction and the magnetic field intensity generated by the first magnetic field generator (7) by feeding the first coil with the polyphase AC current to create the shifting magnetic field control,

characterized in that the apparatus further comprises:

- the first coil is further capable of creating a static magnetic field in accordance with an output of the control means, and
- control means is further adapted for

- depending on the determined stirring

- mode, either feeding the coil with the polyphase AC current to create the shifting magnetic field control or feeding the coil with direct current in the different phases of the polyphase AC current power source and by feeding with different current intensity in the different phases to create the static magnetic field,
- applying a static magnetic field to impart a stabilizing and braking force to a discharge flow from an immersion nozzle when the calculated molten steel flow velocity is higher than the mould powder entrainment critical flow velocity,
 - applying a shifting magnetic field to rotate the molten steel in a horizontal direction when the calculated molten steel flow velocity is lower than the inclusion adherence critical flow velocity and is higher than or equal to a meniscus skinning critical flow velocity, and
 - applying a shifting magnetic field to impart an accelerating force to the discharge flow from the immersion nozzle when the calculated molten steel flow velocity is lower than the meniscus skinning critical flow velocity.
2. Apparatus according to claim 1, wherein the first magnetic field generator is disposed on the long side of the mould.
 3. Apparatus according to claim 1, wherein the apparatus further comprises a second magnetic field generator disposed on the long side of the mould opposite to the first magnetic field generator and comprises a second coil capable of creating a shifting magnetic field and a static magnetic field in accordance with an output from the control means.
 4. Apparatus according to claim 1, wherein the molten steel flow velocity is calculated based on an actually measured molten steel flow velocity or a predicted molten steel flow velocity.
 5. An apparatus according to claim 1, wherein the mould powder entrainment critical flow velocity is 0.32 m/sec and the inclusion adherence critical flow velocity is 0.20 m/ sec.
 6. An apparatus according to claim 1, wherein the meniscus skinning critical flow velocity is 0.10 m/ sec.

Patentansprüche

1. Vorrichtung zum Steuern eines Stahlschmelzeflusses in einer Brammenstranggießmaschine, die eine Kokille (1), welche zum Aufnehmen eines Stahl-

schmelzeflusses angeordnet ist, einen Tauchausguss (4) mit Ausgießöffnungen (5), welche in die Stahlschmelze in der Kokille eingetaucht sind und den Stahlschmelzefluss in die Kokille (1) zuführen, und ein Steuermittel aufweist, wobei die Vorrichtung aufweist:

- Gießzustandserfassungsmittel zum Erfassen mindestens eines Zustands betreffend eine Gießerzeugnisdicke, eine Gießerzeugnisbreite, eine Gießgeschwindigkeit, ein Ausmaß an Inertgaseinblasung in eine Stahlschmelzeausflussöffnung und eine Tauchausgussausgestaltung als Gießzustand,
- Rechenmittel zum Berechnen einer Stahlschmelzefließgeschwindigkeit an dem Gießspiegel der Stahlschmelze in der Kokille entsprechend dem erfassten Gießzustand,
- Bestimmungsmittel zum Bestimmen eines Rührmodus, der darauf basierend anzuwenden ist, ob die berechnete Stahlschmelzefließgeschwindigkeit größer als eine kritische Kokillenpulvermitnahme-Fließgeschwindigkeit ist, ob die Stahlschmelzefließgeschwindigkeit kleiner als eine kritische Einschlussanhaftungs-Fließgeschwindigkeit und größer gleich einer kritischen Gießspiegelhautbildungs-Fließgeschwindigkeit ist und ob die Stahlschmelzefließgeschwindigkeit kleiner als die kritische Gießspiegelhautbildungs-Fließgeschwindigkeit ist, durch Vergleichen der berechneten Stahlschmelzefließgeschwindigkeit mit der kritischen Kokillenpulvermitnahme-Fließgeschwindigkeit, der kritischen Einschlussanhaftungs-Fließgeschwindigkeit und der kritischen Gießspiegelhautbildungs-Fließgeschwindigkeit,
- einen ersten Magnetfeldgenerator (7) zum Erzeugen eines Magnetfelds, der eine erste Spule aufweist, die in der Lage ist, entsprechend einem Ausgang des Steuermittels ein sich bewegendes Magnetfeld zu erzeugen,
- eine mehrphasige Wechselstromquelle, die an den ersten Magnetfeldgenerator angeschlossen ist,
- ein Steuermittel, das dazu ausgebildet ist, die Magnetfeldbewegungsrichtung und die Magnetfeldstärke, welche von dem ersten Magnetfeldgenerator (7) erzeugt werden, durch Speisen der ersten Spule mit dem mehrphasigen Wechselstrom zu steuern, um die Steuerung des sich bewegendes Magnetfeldes bereitzustellen,

dadurch gekennzeichnet, dass bei der Vorrichtung:

- die erste Spule ferner in der Lage ist, ein sta-

tisches Magnetfeld entsprechend einem Ausgang des Steuermittels bereitzustellen, und
- das Steuermittel ferner ausgebildet ist zum:

- in Abhängigkeit von dem bestimmten Rührmodus, entweder Speisen der Spule mit dem mehrphasigen Wechselstrom, um die Steuerung des sich bewegenden Magnetfeldes bereitzustellen, oder zum Speisen der Spule mit Gleichstrom in den verschiedenen Phasen der mehrphasigen Wechselstromquelle und durch Speisen mit unterschiedlicher Stromstärke in den verschiedenen Phasen, um das statische Magnetfeld bereitzustellen,
 - Anlegen eines statischen Magnetfelds, um auf einen Abgabefluss von einem Tauchguss eine stabilisierende und bremsende Kraft auszuüben, wenn die berechnete Stahlschmelzefließgeschwindigkeit größer als die kritische Kokillenpulvermitnahme-Fließgeschwindigkeit ist,
 - Anlegen eines sich bewegenden Magnetfelds, um die Stahlschmelze in eine waagrechte Richtung zu drehen, wenn die berechnete Stahlschmelzefließgeschwindigkeit kleiner als die kritische Einschlussanhaftungs-Fließgeschwindigkeit und größer gleich einer kritischen Gießspiegelhautbildungs-Fließgeschwindigkeit ist, und
 - Anlegen eines sich bewegenden Magnetfelds, um eine Beschleunigungskraft auf den Abgabefluss von dem Tauchguss auszuüben, wenn die berechnete Stahlschmelzefließgeschwindigkeit kleiner als die kritische Gießspiegelhautbildungs-Fließgeschwindigkeit ist.
2. Vorrichtung nach Anspruch 1, wobei der erste Magnetfeldgenerator an der langen Seite der Kokille angeordnet ist.
 3. Vorrichtung nach Anspruch 1, wobei die Vorrichtung ferner einen zweiten Magnetfeldgenerator aufweist, der an der langen Seite der Kokille, die dem ersten Magnetfeldgenerator entgegengesetzt ist, angeordnet ist, und eine zweite Spule aufweist, die in der Lage ist, ein sich bewegendes Magnetfeld und ein statisches Magnetfeld entsprechend einem Ausgang von dem Steuermittel bereitzustellen.
 4. Vorrichtung nach Anspruch 1, wobei die Stahlschmelzefließgeschwindigkeit basierend auf einer tatsächlich gemessenen Stahlschmelzefließgeschwindigkeit oder einer prognostizierten Stahlschmelzefließgeschwindigkeit berechnet wird.
 5. Vorrichtung nach Anspruch 1, wobei die kritische Ko-

killenpulvermitnahme-Fließgeschwindigkeit 0,32 m/s und die kritische Einschlussanhaftungs-Fließgeschwindigkeit 0,20 m/s beträgt.

6. Vorrichtung nach Anspruch 1, wobei die kritische Gießspiegelhautbildungs-Fließgeschwindigkeit 0,10 m/s beträgt.

10 Revendications

1. Appareil de contrôle de l'écoulement d'acier fondu dans une machine de coulée continue, l'appareil comprenant

un moule (1) agencé pour recevoir un écoulement d'acier fondu,
un ajutage immergé (4) comprenant des ouvertures de décharge (5) immergé dans l'acier fondu présent dans le moule et délivrant l'écoulement d'acier fondu dans le moule (1), et des moyens de contrôle,

l'appareil comprenant :

des moyens d'acquisition de l'état de la coulée qui acquièrent au moins un état comme état de coulée concernant l'épaisseur du produit coulé, la largeur du produit coulé, la vitesse de coulée, la quantité de gaz inerte injecté dans une ouverture de sortie d'acier fondu et la forme de la tuyère immergée,
des moyens de calcul qui calculent la vitesse d'écoulement d'acier fondu sur le ménisque de l'acier fondu présent dans le moule selon l'état de coulée qui a été acquis,
des moyens de détermination qui déterminent le mode d'agitation à appliquer selon que la vitesse d'écoulement calculée de l'acier fondu est supérieure à une vitesse critique d'écoulement d'entraînement de poudre dans le moule, selon que la vitesse d'écoulement de l'acier fondu est inférieure à une vitesse critique d'écoulement d'adhérence des inclusions et est supérieure ou égale à une vitesse critique d'écoulement de formation de peau sur le ménisque et selon que la vitesse d'écoulement de l'acier fondu est inférieure à la vitesse critique d'écoulement de formation de peau sur le ménisque, en comparant la vitesse calculée d'écoulement de l'acier fondu à la vitesse critique d'écoulement d'entraînement des poudres dans le moule, à la vitesse critique d'écoulement d'adhérence des inclusions et à la vitesse critique d'écoulement de formation d'une peau sur le ménisque,
un premier générateur (7) de champ magnétique qui produit un champ magnétique et qui comprend une première bobine capable de

créer un champ magnétique de déplacement selon la sortie du moyen de contrôle, une source d'énergie à courant alternatif polyphasé raccordée au premier générateur de champ magnétique, des moyens de contrôle adaptés pour contrôler la direction du déplacement du champ magnétique et l'intensité du champ magnétique produit par le premier générateur (7) de champ magnétique en alimentant la première bobine en courant alternatif polyphasé de manière à créer le contrôle du champ magnétique de déplacement,

caractérisé en ce que

l'appareil présente en outre les caractéristiques suivantes :

la première bobine est en outre capable de créer un champ magnétique statique selon la sortie du moyen de contrôle et les moyens de contrôle sont en outre adaptés pour

- selon le mode d'agitation déterminé, la bobine en courant alternatif polyphasé est alimentée de manière à créer le contrôle du champ magnétique de déplacement ou la bobine en courant continu est alimentée dans les différentes phases de la source d'énergie à courant alternatif polyphasé et en introduisant des intensités de courant différentes dans les différentes phase de manière à créer le champ magnétique statique,
- le champ magnétique statique est appliqué de manière à exercer une force de stabilisation et de freinage sur l'écoulement de décharge hors d'une tuyère immergée lorsque la vitesse calculée d'écoulement de l'acier fondu est supérieure à la vitesse critique d'écoulement d'entraînement des poudres dans le moule,
- un champ magnétique de déplacement est appliqué pour faire tourner l'acier fondu dans une direction horizontale lorsque la vitesse d'écoulement calculée de l'acier fondu est inférieure à la vitesse critique d'écoulement d'adhérence des inclusions et est supérieure ou égale à la vitesse critique d'écoulement de formation d'une peau sur le ménisque, et
- un champ magnétique de déplacement est appliqué pour exercer une for-

ce d'accélération sur l'écoulement de décharge par la tuyère immergée lorsque la vitesse calculée d'écoulement d'acier fondu est inférieure à la vitesse critique d'écoulement de formation d'une peau sur le ménisque.

2. Appareil selon la revendication 1, dans lequel le premier générateur de champ magnétique est disposé sur le long côté du moule.
3. Appareil selon la revendication 1, dans lequel l'appareil comprenant en outre un deuxième générateur de champ magnétique disposé sur le long côté du moule face au premier générateur de champ magnétique et comprend une deuxième bobine capable de créer un champ magnétique de déplacement et un champ magnétique statique selon la sortie du moyen de contrôle.
4. Appareil selon la revendication 1, dans lequel la vitesse d'écoulement de l'acier fondu est calculée sur la base de la vitesse effectivement mesurée d'écoulement de l'acier fondu ou sur la base d'une vitesse prédite d'écoulement de l'acier fondu.
5. Appareil selon la revendication 1, dans lequel la vitesse critique d'écoulement d'entraînement de poudre dans le moule est de 0,32 m/s et la vitesse critique d'écoulement d'adhérence des inclusions est de 0,20 m/s.
6. Appareil selon la revendication 1, dans lequel la vitesse critique d'écoulement de formation d'une peau sur le ménisque est de 0,10 m/s.

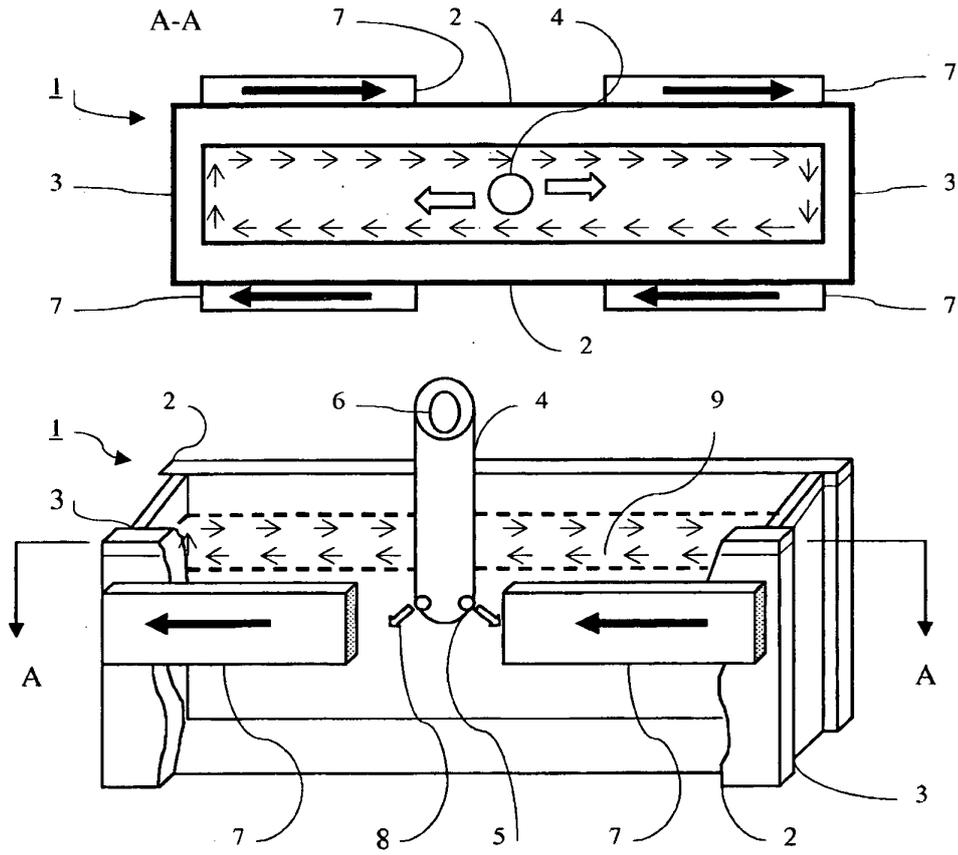


Fig. 1

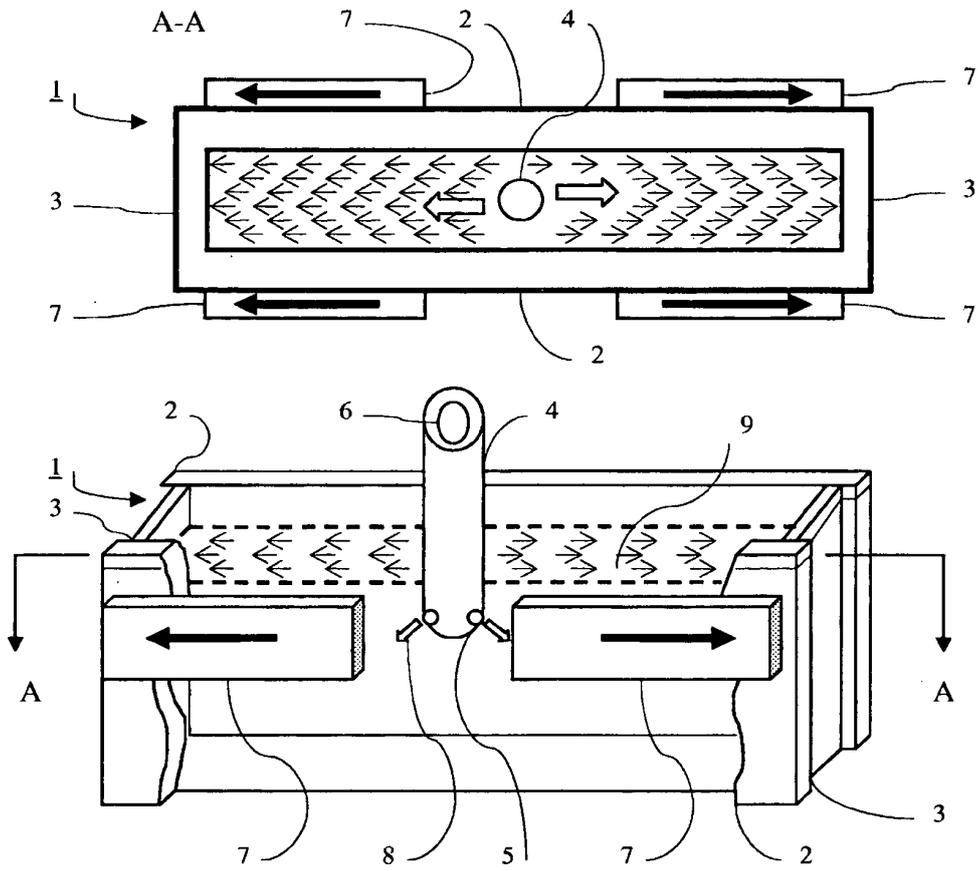


Fig. 2

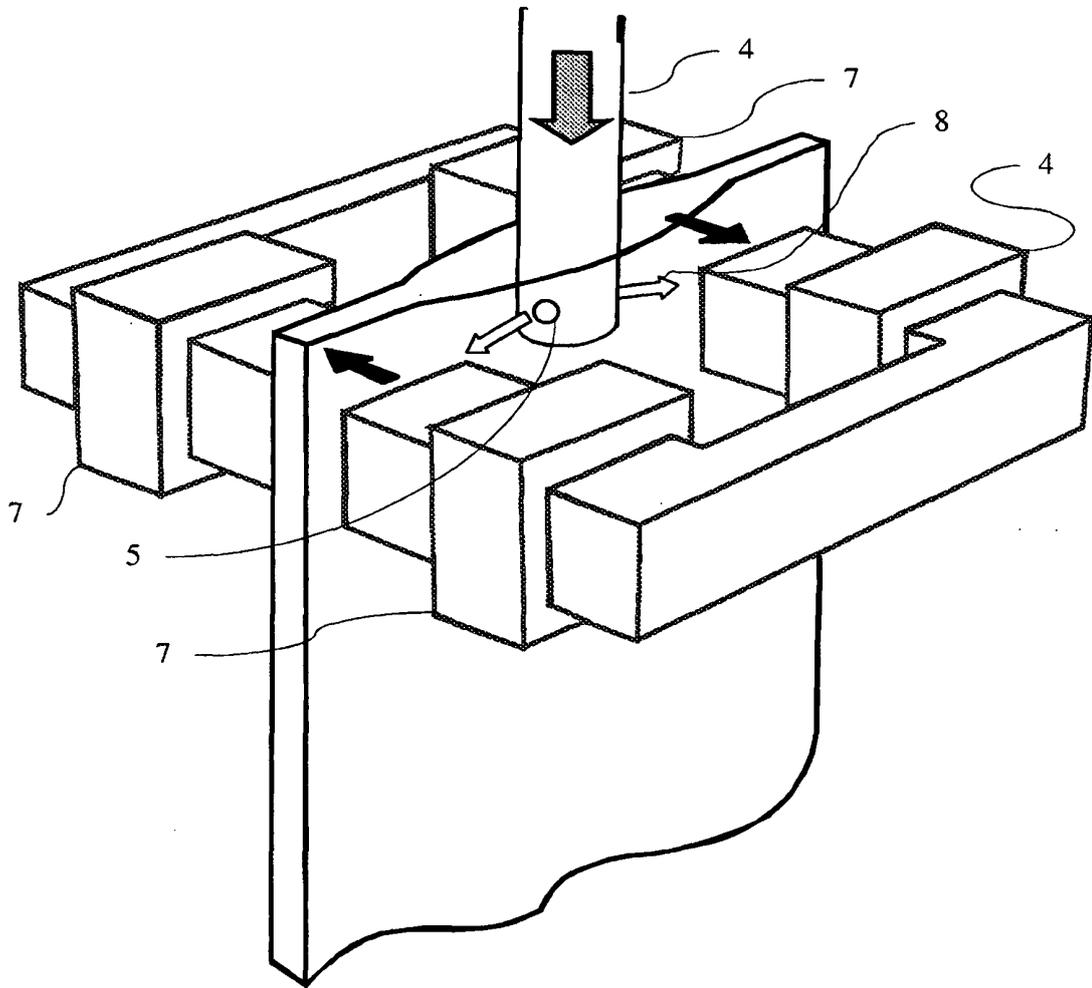


Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1486274 A [0005] [0008]